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Measuring relative efficiency of commercial banks in Bahrain using data envelopment analysis

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Abstract: The study aims at measuring relative efficiency of seven banks listed on Bahrain Bourse under the commercial banks sub-sector over the period 2008-2012 by employing Data Envelopment Analysis (DEA) as a special linear programming model that assesses relative efficiency of decision-making units (DMUs) using multiple incommensurable input and multiple incommensurable output measures. By adopting the production approach of DEA with restricted choice of variables, the study has isolated the relatively efficient banks that achieved total efficiency score from those that could not achieve it. The study has also identified input and output slacks of inefficient banks and suggested the efficient input and output targets for improvement.

Keywords: Efficiency, Commercial Banks, DEA, Slacks, Linear Programming, Bahrain

1. Introduction

Commercial banks are one of the most important financial institutions of an economy. Many studies indicate that the efficiency of the financial intermediation of commercial banks affects economic growth and that the insolvencies of these banks can result in systemic crisis or initiate negative consequences for the economy. Therefore, the performance of commercial banks has been always an issue of great interest for various stakeholders such as regulators, shareholders, depositors and loan customers.

The banking sector has played an important role in the emergence of Bahrain as leading financial hub in the GCC Countries and in the region as well. According to the Fact Sheet of Central Bank of Bahrain, banking sector assets, as of July 2014, are over US$193 billion with a 23 retail banks, 69 wholesale banks, 2 specialized banks as well as 36 representative offices of overseas banks. The Islamic banking segment offers Sharia compliant products with 6 retail banks and 18 wholesale banks, and has total assets of US$24.6 billion. Bahraini banking sector over time has shown a tremendous growth. It is an open market. Government implements stable and prudent macro-economic and fiscal policies. Central Bank of Bahrain is keen to establish a credible regulatory framework in line with international standards. Local labor market offers very skillful and well qualified workforce. Bahrain has still an affordable cost of living compared to many of its neighbors. All these factors may have combined to secure Bahrain as a regional banking hub. Despite worldwide challenges, Bahrain has a stable banking system with observed growth opportunity in the sector.

This paper attempts not only to determine the commercial banks listed on Bahrain Bourse that have total relative efficiency based on the data available over the period of 2008 to 2012 but also to identify the banks which are unable to achieve that efficiency by exploring primary reasons lying behind. It also illustrates the efficient peers and weights of the banks and suggests the efficient input and output targets of inefficient ones by determining the inputs and outputs slacks. For this purpose, this study employs Data Envelopment Analysis (DEA) as a widely used a linear programming model to assess relative efficiency of decision-making units (DMUs), viz. banks, that use multiple incommensurable inputs and multiple incommensurable outputs.Study provides review of the literature; describes the data and presents the method; discusses empirical findings; and finally closes with concluding remarks.

2. Literature Review

A large part of existing literature examines the efficiency of conventional banks using DEA. Examples of previous studies that used DEA to assess relative efficiency of banks include Marie et al (2013), Johnes et al. (2012), Qureshi et al. (2012), Bilal et al. (2011), Rahman (2011), Srairi (2011), AlKhathlan and Malik (2010), Shahid et al (2010), Srairi (2010), Kamaruddin et al. (2008), and Mostafa (2007).

Marie et al (2013) examined 18 banks in Dubai applying a parallel DEA to measure the operational profitability and quality in 2008 based on data collected from financial statements and randomly selected bank customers. They found no statistical difference between Islamic and commercial banks in the operational profitability, however, Islamic banks dominated the commercial ones in the operational quality. They also pointed out that operational quality in Islamic banks depended on the assurance, responsiveness and reliability factors.

Johnes et al. (2012) compared, using DEA approach, the performance of 210 conventional and 45 Islamic banks from 19 countries for the period 2004-2009. They found out that there was no significant difference in mean efficiency between the two types of banks when efficiency is measured relative to a common frontier. A meta-frontier analysis, however, revealed some fundamental differences between the two bank groups. They also emphasized that the Islamic banks was less efficient than the conventional one. Managers of Islamic banks made up for this as mean efficiency in Islamic banks was higher than in conventional banks when efficiency was measured relative to their own bank type frontier.

Qureshi et al. (2012) analyzed comparative efficiency of banking system in Pakistan by considering the Islamic banks, conventional banks with Islamic banking division and conventional banks across 2003-2008. They used both ratio analysis and DEA approach. The research results indicated that Islamic banks were more cost efficient and less revenue efficient. Considering their high growth rate, it was recommended that Islamic banks should be encouraged to reach the efficient frontier by reducing their wastes. It was also determined that hybrid banking is not feasible form of banking in Pakistan.

Bilal et al. (2011) investigated the efficiency of 5 private Islamic banks and 5 private conventional banks of Pakistan for 2006-2008. Non-parametric DEA method was used. Intermediation approach was applied for the specification of inputs and outputs. The findings suggested that scale inefficiency was dominated by the pure technical inefficiency effects in determining Islamic bank's technical inefficiency. It was concluded that Islamic banks were more efficient in operating at an optimum size though they were managerially not that much efficient. The opposite was valid for commercial banks.

Rahman (2011) examined the efficiency of Islamic and conventional banks in Bangladesh using different parametric and non-parametric approaches over the study period of 2003-2008. His results showed that conventional and Islamic banks improved and converged to the highest level of efficiency. Findings also showed that conventional banks were only slightly more efficient than Islamic banks.

Srairi (2011) examined, in the GCC region, the effects of financial liberalization on banking productivity growth for the period of 1999 and 2007. He, based on non-parametric DEA, measured productivity change computing a Malmquist total factor productivity index for Islamic and conventional banks. The results showed that during the deregulation period, banks in GCC region experienced a gain in productivity change attributed mainly to technical change rather than to an increase in efficiency. He also noted that conventional banks tended to outperform Islamic ones in most productivity measures.

AlKhathlan and Malik (2010) implemented DEA to ten commercial banks operating in Saudi Arabia to analyze both the technical and scale efficiencies of these banks during 2003-2008. They claimed that their findings showed that there was efficient management of financial resources by Saudi banks.

Shahid et al (2010) investigated the efficiency of banking sector in Pakistan based on DEA using data gathered both from Islamic and conventional banks over the period of 2005 and 2009. The findings indicated that the technical efficiency of conventional banks was better than the Islamic ones but about the cost and allocative efficiency, both groups show a healthy competition.

Srairi (2010) investigated 11 local commercial banks of Saudi Arabia for the period of 1999 and 2007. He adopted DEA so as to compute five different measures of efficiency including cost, allocative, technical, pure and scale efficiencies. He pointed out that the cost efficiency was below the world mean and during the period of liberalization between the years of 2003-2007, most efficiency scores slightly increased. The results also showed that the dominant source of cost efficiency was due to allocative inefficiency rather than technical one.

Kamaruddin et al. (2008) investigated both cost and profit efficiency of Islamic banks and Islamic window operations of domestic and foreign commercial banks over 1998-2004 in Malaysia. DEA was applied to several efficiency measures such as allocative, pure technical and scale efficiency. The findings revealed that Islamic banking operators were relatively more efficient at controlling cost than at generating profits.

Mostafa (2007) attempted to measure the relative efficiency of the top 100 Arab banks using cross sectional data via DEA for the year 2005. His findings indicated that the performances of several banks were sub-optimal.

3. Model and Data

DEA is commonly used to evaluate the efficiency of a group of production units (originally known as Decision Making Units DMUs) such as banks. In DEA, each DMU is compared with only the "best" DMUs. DEA computes a

scalar measure of efficiency (called efficiency score) and determines efficient levels of inputs and outputs for the DMU under evaluation. In general there are two approaches that a DMU in a DEA model can be considered. The first is called the *Intermediary Approach*. According to this approach a bank is a financial vehicle that borrows funds from depositors and lends them for profit. In this case the banks' outputs are loans and the inputs are different costs of these funds such as interest expenses, labor, capital and operating costs. On the other hand, there is the *Production Approach* where a bank is an organization that uses capital and labor to produce loans and deposit account services. The banks' inputs are labor, capital and operating costs in order to produce accounts and transactions as outputs (Berger and Humphrey, 1997).

The current study adopts the production approach with restricted choice of variables in order to measure the efficiency of any DMU is obtained as the maximum of a ratio of weighted outputs to weighted inputs subject to the condition that the similar ratios for every DMU should be less than or equal to unity. In more precise form,

$$Max\ h_0 = \sum_{r=1}^{S} u_r y_{r0} \div \sum_{i=1}^{m} v_i x_{i0}$$

Subject to:

$$\{\sum_{r=1}^{S} u_r y_{ri} \div \sum_{i=1}^{m} v_i x_{ij}\} \le 1;\ j=1,2,...,n.$$

$$u_r, v_i \ge 0;\quad r=1,2,...s;\quad i=1,2,...,m$$

The y_{rj}, x_{ij} (all positive) are the known outputs and inputs of the j^{th} DUM and the ur, vi ≥ 0 are the variable weights to be determined by the solution of this problem using the data on all of the DUM's which are being used as a reference set. The efficiency of one member of this reference set of j=1,2,..,n is to be rated relative to other DMUs. The indicated maximization objective function then accords this DMU the most favorable weighting that the constraints allow.

For the DMU's which concern us, the x_{ij} and y_{rj} values, which are constants, will usually be observations from past decisions on inputs and outputs that resulted there from. We can, however, replace some or all of these observations by theoretically determined values if we wish (and are able) to conduct our efficiency evaluations in that manner.

3.1. Study Variables

Banking sector employs multiple inputs to produce multiple outputs. To capture important components of banks' resources and outputs within the available data, three input variables and two output variables were sought to measure the technical relative efficiency, as shown in table (1)

Table 1. *Input and Output Variables*

Inputs	Output
Total deposits Overhead expenses Total Owners' Equity	Net loans Interest income

The two outputs taken into consideration are net loans and interest income (which includes interest of bonds, certificates of deposit and other interest). On the other hand the inputs used are: total deposits, overhead expenses and equity. To ensure meaningful efficiency scores, the number of DMUs must be large enough to the total number of inputs and output as suggested by Boussofiane et al. (1991).

3.2. Sources of Data

The data for this study were collected from BANKSCOPE and commercial banks' annual reports. Table 2 shows the input and output variables of seven Bahraini retail commercial banks over the period (2008-2012), while Table 3 presents the descriptive statistics of the selected inputs and outputs for the same study period. All the data employed are expressed in Million Bahraini Dinars. Table 4 illustrates that there is strong correlation among study variables(input and output).

Table 2. *Input and Output Data for 2008-2012 (Figures in million BDs)*

Variables Banks		Inputs			Output	
		Total Deposit	Overhead Expenses	Equity	Net Loans	Interest Income
	B1	13,075	53.9	726.6	4,895.10	108.8
	B2	2,923.70	35.1	209.3	1,352.30	56.6
	B3	3,324.30	24.1	217.4	1,095.70	49.4
2008	B4	867.5	14.2	128.6	486.90	15.5
	B5	542.3	3.4	63.3	113.10	13.8
	B6	4,968.10	57.6	902.8	5,139.30	467.5
	B7	600.60	12.4	137.9	140.10	43.5
	B1	6,834	46.3	671.5	3,508.70	77.9
	B2	3,273.40	43	231	1,268.60	57
	B3	3,346.20	25.8	241.4	1,151.40	52.7
2009	B4	747.7	15.3	112.6	388.00	15.3
	B5	530.4	3.5	73.7	118.40	13.2
	B6	4,992	53.6	973.2	5,014.10	352.2
	B7	579.1	10.3	126.6	192.10	22

Variables Banks		Inputs			Output	
		Total Deposit	Overhead Expenses	Equity	Net Loans	Interest Income
	B1	6,086	37.1	723.8	2,834	58.9
	B2	3,384.40	45.6	240.5	1,276.30	56.6
	B3	3,768.80	25.8	263	950.8	52.4
2010	B4	728	17.3	86.4	310	14.5
	B5	502.7	5.1	88.2	151.7	14.4
	B6	5,593.10	53.7	1,037.60	5,458.10	336.8
	B7	503.60	16.3	118.2	203.2	17.9
	B1	7,121	45.2	740.7	2,547.80	57
	B2	4,295.90	47.9	238	1,406.70	61.4
	B3	4,008.60	26.7	274.7	972.1	60
2011	B4	936.1	18.9	82.9	349.6	13.6
	B5	513.2	5.1	96.6	141.2	20.9
	B6	6,539.10	55	1,097.50	5,842	367.2
	B7	553.70	17.2	118.9	201.6	21.6
	B1	8,212	51.4	803.8	2,683.10	60.7
	B2	4,712	50.5	289.7	1,498.70	67.9
	B3	4,399.70	27.3	318.9	888.2	65.4
2012	B4	1,184.60	18.7	85.4	499.1	15.5
	B5	518	6.2	104.5	112.7	20
	B6	6,880	56.2	1,206.40	6,027.30	404
	B7	576.8	15.3	119.5	245.7	16.6

Source: Compiled from BANSCOPE and Commercial Banks' Annual Reports

Table 3. *Descriptive Statistics*

Years		Total Deposit	Overheads Expenses	Equity	Net Loans	Interest Income
2008	Maximum	13,075	57.6	902.8	5,139.30	467.5
	Minimum	542.30	3.4	63.30	113.1	13.80
	Mean	3,757	28.671	341	1888.929	108
	Standard Deviation	4102.61	19.451	307.155	2024.73	149.717
2009	Maximum	6,834	53.6	973	5014.1	352
	Minimum	530	3.5	74	118.4	13
	Mean	2,900	28.257	347	1663.043	84
	Standard Deviation	2262.278	18.104	316.283	1,741.45	111.621
2010	Maximum	6,086	53.7	1,037.60	5458.1	336.80
	Minimum	502.70	5.1	86.40	151.7	14.40
	Mean	2,938	28.7	365	1597.729	79
	Standard Deviation	2,222.97	16.17	342.715	1798.67	106.998
2011	Maximum	7,121	55	1,097.50	5842	367.20
	Minimum	513.20	5.1	82.90	141.2	13.60
	Mean	3,424	30.857	378	1637.286	86
	Standard Deviation	2618.74	17.276	375.974	1888.38	116.38
2012	Maximum	8,212	56.2	1206.4	6,027.30	404
	Minimum	518	6.2	85	112.7	16
	Mean	3,783	32.228	418	1707.829	93
	Standard Deviation	2882.024	18.698	395.457	1944.508	128.912

Source: Computed using Table (1) data

Table 4. *Nonparametric Correlations*

		Total Deposit	Overheads Expenses	Equity	Net Loans	Interest Income
Total Deposit	Correlation Coefficient	1				
	Sig. (1-tailed)	-				
	N	7				
Overheads Expenses	Correlation Coefficient	.905**	1			
	Sig. (1-tailed)	0.002	-			
	N	7	7			
Equity	Correlation Coefficient	.619*	.714*	1		
	Sig. (1-tailed)	0.025	0.012	-		
	N	7	7	7		
Net Loans	Correlation Coefficient	.905**	1.000**	.714*	1	
	Sig. (1-tailed)	0.002	.	0.012	-	

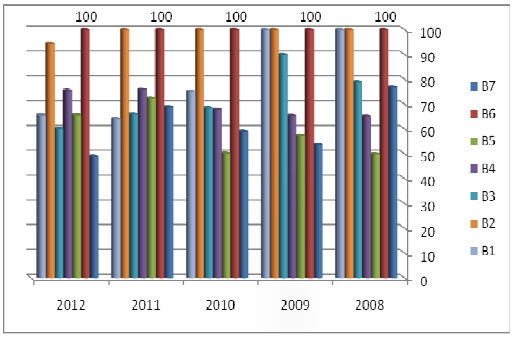
		Total Deposit	Overheads Expenses	Equity	Net Loans	Interest Income
	N	7	7	7	7	
	Correlation Coefficient	.829*	.724*	.819*	.924*	1
Interest Income	Sig. (1-tailed)	0.008	0.049	0.025	0.049	-
	N	7	7	7	7	7

Source: Calculated by researchers by using SPSS software.
**. Correlation is significant at the 0.01 level (1-tailed).
*. Correlation is significant at the 0.05 level (1-tailed).

4. Empirical Results and Discussion

Using the DEA Software and the available data for the seven Bahraini retail commercial banks, we computed the relative efficiency of these banks over the period of 2008 to 2012 and shown below in Figure (1).

According to Figure 1, the retail commercial banks that are efficient (non zero slacks) are: B1, B2, and B6 in years 2008 and 2009. B2 and B6 in years 2010 and 2011, while in year 2012 B5 and B6 were efficient. B4 appears to be the less efficient bank and B3 is close to become relatively efficient.



Source: calculated by researchers by using DEA frontier software

Figure 1. *Relative Efficiency of Each Retail Commercial Bank (2008-2012)*

Table 5 presents the efficient peers of each DMU and the relevant weight, the lambda value, so that a virtual DMU can be formed as a weighted combination of some efficient DUMs. For instance in year 2008, B3 has as efficient peers B1, B2 and B6. So the reference set of B3 is {B1, B2, B6} with weights {0.082, 0.344, 0.045}. For B3 the results 0.082, 0.344 and 0.045 indicate that the target of this DMU is to become 8.2% of B1, 34.4% of B2 and 4.5% of B6. In year 2009 B3 still has as efficient peers B1, B2, and B6 with different weights {0.102, 0.340, 0.072}, while in year 2010 and 2011 the reference banks of B3 are B2 and B6 with weights {0.252, 0.115} and {0.041, 0.157} respectively. In year 2012, B6 was the reference bank of B3 with weight 0.159.

DMU movements towards efficient operation cloud involve scaling up or scaling down of size based on the efficiency of a hypothetical best-practice composite reference unit. This hypothesis identifies inputs that have to be reduced and output that need to be increased in order to make a particular DMU efficient. This information may help the decision makers to determine whether the size of reprehensive DMU in the particular industry is appropriate or not (Kumar and Gulati, 2008).

The range of improvements (in Million BDs) needed for DMUs inputs and outputs to reach the efficiency are illustrated in Tables 6-10 (based on CRS assumption with input orientation). Table 6 shows the potential improvement in year 2008 for inefficient banks (B3, B4, B5, and B7) whereas B1, B2 and B6 are efficient and, therefore require no change in their inputs and outputs.

Table 5. *Efficient Peers and Weights of Retail Commercial Banks (2008-2012)*

DMU No.	DMU Name	Input-Oriented CRS Efficiency	Sum of lambdas	RTS	Optimal Lambdas with Benchmarks					
2008										
1	B1	1.00000	1.000	Constant	1.000	B1				
2	B2	1.00000	1.000	Constant	1.000	B2				
3	B3	0.79068	0.470	Increasing	0.082	B1	0.344	B2	0.045	B6
4	B4	0.65218	0.138	Increasing	0.059	B2	0.079	B6		
5	B5	0.50008	0.030	Increasing	0.030	B6				
6	B6	1.00000	1.000	Constant	1.000	B6				
7	B7	0.76968	0.093	Increasing	0.093	B6				
2009										
1	B1	1.00000	1.000	Constant	1.000	B1				
2	B2	1.00000	1.000	Constant	1.000	B2				
3	B3	0.90026	0.515	Increasing	0.102	B1	0.340	B2	0.072	B6
4	B4	0.65446	0.147	Increasing	0.058	B1	0.070	B2	0.019	B6
5	B5	0.57396	0.037	Increasing	0.037	B6				
6	B6	1.00000	1.000	Constant	1.000	B6				
7	B7	0.53846	0.062	Increasing	0.062	B6				
2010										
1	B1	0.75155	0.519	Increasing	0.519	B6				
2	B2	1.00000	1.000	Constant	1.000	B2				

DMU No.	DMU Name	Input-Oriented CRS Efficiency	Sum of lambdas	RTS	Optimal Lambdas with Benchmarks			
3	B3	0.68522	0.367	Increasing	0.252	B2	0.115	B6
4	B4	0.67998	0.122	Increasing	0.085	B2	0.037	B6
5	B5	0.50298	0.043	Increasing	0.043	B6		
6	B6	1.00000	1.000	Constant	1.000	B6		
7	B7	0.59027	0.053	Increasing	0.053	B6		
2011								
1	B1	0.64109	0.545	Increasing	0.144	B2	0.401	B6
2	B2	1.00000	1.000	Constant	1.000	B2		
3	B3	0.66091	0.197	Increasing	0.041	B2	0.157	B6
4	B4	0.75547	0.148	Increasing	0.116	B2	0.032	B6
5	B5	0.72523	0.057	Increasing	0.057	B6		
6	B6	1.00000	1.000	Constant	1.000	B6		
7	B7	0.69470	0.059	Increasing	0.059	B6		
2012								
1	B1	0.65689	1.016	Decreasing	0.623	B4	0.394	B6
2	B2	0.94472	1.912	Decreasing	1.813	B4	0.099	B6
3	B3	0.60303	0.159	Increasing	0.159	B6		
4	B4	1.00000	1.000	Constant	1.000	B4		
5	B5	0.65752	0.050	Increasing	0.050	B6		
6	B6	1.00000	1.000	Constant	1.000	B6		
7	B7	0.49011	0.041	Increasing	0.041	B6		

Table 6 shows that the efficiency of B3 can be improved by decreasing total deposits from 3324.3 to 2295.256 (a slack of 1029.044), and increasing net loans from 1095.7 to 1097.70001. The efficiency of B4 can be improved by decreasing the overheads expenses by 2.6 to reach 6.63 and increasing interest income by 24,884 to reach its 40.384. The efficiency of B5 can be achieved by decreasing total deposits and equity by 124.542 and 5.005 respectively, moreover, increasing net loans by 38.605. The efficient input target of B7 is decreasing the overheads expenses and equity to 8.359 and 105.6 respectively and increasing net loans to 478.202 Million Bahraini Dinars.

Table 7 shows the areas of improvements in year 2009 for Banks B3, B4, B5 and B7 while B1, B2 and B6 are efficient and they do not need any adjustment in their inputs and outputs.

It can be deducted from Table 7 that the efficiency of B3 can be improved by decreasing total deposits to 1763.042 (a slack of 1249.412).The efficiency of B4 can be improved by decreasing the overheads expenses from 15.3 to 11.718. The efficiency of B5 can be achieved by decreasing total deposits and equity to 187.09 and 36.474 respectively, and increasing net loans to187.921, the efficient input target of B7 is to decrease the overheads expenses and equity by 2.198 and 7.378 respectively and increasing net loans by 121.103 Million BD.

Table 6. *CRS Model Slacks and Model Target for 2008*

CRS Model Slacks						
		Input Slacks			**Output Slacks**	
DMU No.	DMU Name			Input	Output	
1	B1	0.00000	0.00000	0.00000	0.00000	0.00000
2	B2	0.00000	0.00000	0.00000	0.00000	0.00000
3	B3	1029.044	0.00000	0.00000	0.00001	0.00000
4	B4	0.00000	2.63072	0.00000	0.00000	24.88467
5	B5	124.54242	0.00000	5.00568	38.60554	0.00000
6	B6	0.00000	0.00000	0.00000	0.00000	0.00000
7	B7	0.00000	4.18451	22.13562	338.10224	0.00000
CRS Model Target						
		Efficient Input Target			Efficient Output Target	
DMU No.	*DMU Name*				Output	
1	B1	13075.00000	53.90000	726.60000	4895.10000	108.80000
2	B2	2923.70000	35.10000	209.30000	1352.30000	56.60000
3	B3	2295.25634	24.05542	217.39409	1095.70001	49.40000
4	B4	867.46281	6.63018	128.6123	486.90000	40.38467
5	B5	146.65194	3.40028	57.64950	151.70554	13.80000
6	B6	4968.10000	57.60000	902.80000	5139.30000	467.50000
7	B7	600.60240	8.35957	105.60385	478.20224	43.50000

Table 7. *CRS Model Slacks and Model Target for 2009*

CRS Model Slacks						
		Input Slacks			Output Slacks	
DMU No.	DMU Name			Input	Output	
1	B1	0.00000	0.00000	0.00000	0.00000	0.00000
2	B2	0.00000	0.00000	0.00000	0.00000	0.00000
3	B3	1249.41223	0.00000	0.00000	0.00001	0.00000
4	B4	0.00000	3.29487	0.00000	0.00000	0.00000
5	B5	117.33448	0.00000	5.82655	69.52197	0.00000
6	B6	0.00000	0.00000	0.00000	0.00000	0.00000
7	B7	0.00000	2.19805	7.37872	121.10329	0.00000
CRS Model Target						
		Efficient Input Target			Efficient Output Target	
DMU No.	*DMU Name*			Input	Output	
1	B1	6834.00000	46.30000	671.50000	3508.70000	77.90000
2	B2	3273.40000	43.00000	231.00000	1268.60000	57.00000
3	B3	1763.04213	25.72674	241.32308	1151.40001	52.70000
4	B4	747.74207	11.71841	112.69255	388.00000	15.30000
5	B5	187.09370	3.50886	36.47428	187.92197	13.20000
6	B6	4992.00000	53.60000	973.20000	5014.10000	352.20000
7	B7	579.12283	8.24810	118.79046	313.20329	22.00000

Table 8. *CRS Model Slack and Model Target for 2010*

CRS Model Slacks						
		Input Slacks			**Output Slacks**	
DMU No.	DMU Name			Input	Output	
1	B1	1669.84650	0.00000	185.22168	-0.00002	115.97609
2	B2	0.00000	0.00000	0.00000	0.00000	0.00000
3	B3	1085.02923	0.00000	0.00000	0.00002	0.68896
4	B4	0.00000	5.89146	0.00000	0.00000	2.73666
5	B5	13.71375	0.26924	0.00000	81.66294	0.00000
6	B6	0.00000	0.00000	0.00000	0.00000	0.00000
7	B7	0.00000	6.76733	14.62384	86.88310	0.00000
CRS Model Target						
		Efficient Input Target			Efficient Output Target	
DMU No.	*DMU Name*			Input	Output	
1	B1	4416.16580	37.18256	538.75128	2833.99998	174.87609
2	B2	3384.40000	45.60000	240.50000	1276.30000	56.60000
3	B3	2683.78842	25.7787	263.21360	950.80002	53.08896
4	B4	727.72395	11.87216	85.4009	310.00000	17.23666
5	B5	488.13491	4.89596	88.16294	233.36294	14.40000
6	B6	5593.10000	53.70000	1037.60000	5458.10000	336.80000
7	B7	503.56798	9.85401	104.14561	290.08310	17.90000

Table 8 illustrates the areas of improvements in year 2010 for banks, B1, B3, B4, B5 and B7, while B2 and B6 are efficient. As shown B1 needs a lot of adjustments to achieve efficiency, where B1 needs to decrease total deposits and equity by 27% and 34.4% respectively, and increasing interest income by 197% (from 58.9 to 174.87). The efficiency of B3 can be improved by decreasing total deposits by 28% (a slack of 1085.02) and increasing interest income by almost 1% (a slack of 0.688). The efficiency of B4 can be improved by decreasing the overheads expenses by 34% and increasing interest income by 19%. The efficiency of B5 can be achieved by decreasing total deposits and equity by 2% and 0.5% respectively and increasing net loans by 8% (from 151.7 to 233.36). The efficient input target of B7 is to decrease the overheads expenses and equity by 41.5% and 12.4% respectively and increasing net loans by 42.7%.

Table 9 shows the same results that illustrated in table(8), where Banks, B1, B3, B4, B5, and B7 are still need some improvements in inputs and outputs to reach the efficiency, while Banks B2 and B6 are efficient and require no changes in their inputs and outputs. The big adjustment should happen in B7 in order to improve it and reach efficiency, where B7 should decrease its overheads expenses from 17.2 to 3.23, decrease equity from 118.9 to 64.5, and increase net loans from 201.6 to 343.647 Million BDs.

Table 10 shows the areas of improvements in year 2012 for inefficient banks, which are B1, B2, B3, B5 and B7, whereas only banks B4 and B6 are efficient and require no changes in their inputs and outputs. The efficiency of B1 can be improved by decreasing total deposits from 8212 to 6263.2 and increasing interest income from 60.7 to 168.6. The efficiency of B2 can be improved by decreasing total deposits from 4712 to 3087.69 and decreasing the overheads expenses from 50.5 to 42.44.

Table 9. *CRS Model Slack and CRS Model Target for 2011*

CRS Model Slacks						
		Input Slacks			**Output Slacks**	
DMU No.	DMU Name			Input	Output	
1	B1	1321.49580	0.00000	0.00001	-0.00002	99.25155
2	B2	0.00000	0.00000	0.00000	0.00000	0.00000
3	B3	1450.27131	7.08140	0.00000	0.00002	0.00000
4	B4	0.00000	6.96428	0.00000	0.00000	5.23806
5	B5	0.00000	0.56822	7.59045	191.31035	0.00000
6	B6	0.00000	0.00000	0.00000	0.00000	0.00000
7	B7	0.00000	13.71347	54.40048	142.04706	0.00000
CRS Model Target						
		Efficient Input Target			Efficient Output Target	
DMU No.	*DMU Name*			Input	Output	
1	B1	5799.51635	45.20000	740.65642	2547.79998	156.25155
2	B2	4295.90000	47.90000	238.00000	1406.70000	61.40000
3	B3	2558.3433	19.56485	274.36142	972.10002	60.00000
4	B4	93619201	12.31404	82.92816	349.60000	18.83806
5	B5	513.18733	4.63045	89.46664	332.51035	20.90000
6	B6	6539.10000	55.00000	1097.50000	5842.00000	367.20000
7	B7	553.65294	3.23529	100.55882	343.64706	21.60000

Table 10. *CRS Model Slack and Model Target for 2012*

CRS Model Slacks						
		Input Slacks			**Output Slacks**	
DMU No.	DMU Name			Input	Output	
1	B1	1948.83645	0.00000	0.00000	-0.00001	107.96413
2	B2	1625.81950	8.26421	0.00000	-0.00001	0.00000
3	B3	1556.45283	7.50420	0.00000	72.58742	0.00000
4	B4	0.00000	0.00000	0.00000	0.00000	0.00000
5	B5	0.00000	1.29443	8.98781	185.68119	0.00000
6	B6	0.00000	0.00000	0.00000	0.00000	0.00000
7	B7	0.00000	5.18941	8.99775	1.95639	0.00000
CRS Model Target						
		Efficient Input Target			Efficient Output Target	
DMU No.	*DMU Name*			Input	Output	
1	B1	6263.17116	51.36431	803.81082	2683.09999	168.66413
2	B2	3087.69595	42.44409	289.68506	1498.69999	67.90000
3	B3	2843.71287	20.95861	318.90733	960.78742	65.40000
4	B4	1184.60000	18.70000	85.40000	499.10000	15.50000
5	B5	518.09406	5.08218	95.72277	298.38119	20.00000
6	B6	6880.00000	56.20000	1206.40000	6027.30000	404.00000
7	B7	576.79307	10.20921	100.56990	247.65639	16.60000

5. Conclusion and Recommendations

5.1. Conclusions

Based on the study results, 4 banks out of 7 were technically inefficient under variable returns to scale (VRS), with an overall average score of 0.816 (81.6%) during years 2008 and 2009, while 5 banks out of 7 were technically inefficient under variable returns to scale (VRS), with an overall average score of 0.754 (75.4%) during years 2010, 2011 and 2012. These results are consistent with other studies carried out in developing countries, which showed that technical inefficiency exists in the banking sector.

The allocative efficiency scores averaged around 0.917 for the banks under study over the period (2008-2012). Bank 6 (B6) is found to be the most allocative efficient and realized an efficient score the highest, while Bank 5 (B5) found to be the least for years 2008 to 2010 and Bank 7(B7) was the least for years 2011 and 2012.

The DEA model provides useful information on inefficient banks to achieve efficiency by either decreasing inputs and/or increasing outputs, where it provides the actual and target values of inputs and outputs for the technically inefficient banks as shown in tables (6-10).

Finally, while the kingdom of Bahrain has implemented many economic and financial reforms over the last decades or so, these do appear to have positive impact on the efficiency of the sample of retail commercial banks under

study and it shows an increasing trend in performance of these banks caused by IT innovation, competition, better supervision, and enlarged investment in new information technology during the recent time period. The banks were left with no option but to improve their functional operations, strategies and policies. In this paper, the authors' propose was to assess banks' relative efficiencies and to recommend further research areas. In comparison with international standards, Bahraini banks would need to improve their technological orientation, to continue their efforts to reduce the percentage of non-performing assets and expand the possibilities for augmenting their financial activities in order to improve their profit efficiency in the near future.

5.2. Recommendations for Further Study

The paper could be extended in a variety of ways. Firstly, the scope of the paper could be extended to compare relative efficiency of commercial banks with that of Islamic banks. Secondly, the performance of commercial banks could be extended by considering the risk exposure factor. Thirdly, future research could investigate changes in productivity of commercial banks over time as a result of technical change or technological progress or regress by employing the Malmquist total factor productivity index.

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